Estimating cost functions for biodiversity provision Swedish forests

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Estimation of cost functions for preserving biodiversity in Swedish forests

1. Introduction

Payments as incentives for promoting provision of different types of ecosystem services (PES) have been introduced in several countries. The PES programs were first introduced mainly in the agricultural sectors for water quality improvements in EU, USA, and Australia (OECD, 2003), but have emerged as an important instruments for providing several types of ecosystem services. The basic idea of PES is to internalise the production of non-market services into the land owner's decision problem creating a trade off between the production of different market and non-market goods. Simple economic theory then predicts that the supply of land for biodiversity protection is increasing in compensation payment, where the latter represent the opportunity cost of land. Given sufficient data it is then in principle possible to estimate a cost function for biodiversity protection, which is of great use for decision making on policies for biodiversity protection. However, in spite of the emerging importance of biodiversity protection and the early introduction of PES, there are, to the best of our knowledge, no studies estimating cost functions on the basis of actual payments. The purpose of this study is to carry out such estimates for Sweden, which is made by means of panel data of actual payments and land enrolment for two types of compensation schemes; a mandatory set a side program and a voluntary biodiversity management program

There is a relatively large empirical literature on the optimal site selection for provision of biodiversity which relies on value of land as the opportunity cost of land conversion (e.g. Ando et al. 1998; Polasky et al., 2001; Wu and Skeleton 2002; Costello and Polasky 2004; Nalle et al., 2004; Newburn et al, 2006; Lewis and Plantinga, 2009). There is also an emerging literature on the determinants of compensation payments, which includes not only factors affecting the market value of land but also land owners' attitudes and household characteristics (Sikkimäki and Layton, 2007; Barton et al., 2009; Börner et al. 2009; Layton and Siikamäki 2009; Illukpitiya and Yanagida, 2010). The estimates of the explanatory power of different variables for enrolment in conversion programs are based on stated and not revealed preferences. In fact, we have found only two studies estimating costs of biodiversity from revealed preferences (Connor et al.,2008; Jack et al., 2009). Common to both studies is that only land is included as an explanatory variable. We don't find any study that estimates biodiversity cost functions based on actual compensation payments as a function of, not only land, but also on other factors, such as prices of forestry output and input which impact the value of forest land.

The paper is organized as follows. We first give a simple theoretical framework underlying the choices of dependent and independent variables. The data are presented in Section 3, and the results are given in Section 4. The paper ends with some tentative conclusions.

2. Simple theoretical background

The basic is that the land owners are compensated for the opportunity cost of land set aside for biodiversity conservation. This is, in turn, derived from a decision problem where the land owners are assumed to maximise current and future streams of net benefits from forestry. Starting in mid 1900s there is a large theoretical literature on optimal forestry (see Pong and Löfgren 2009 for a review). In this paper, the derivation of explanatory variables and assessment of signs of estimated coefficients are based on a very simple decision problem where land owner's maximises discounted current and future streams of net benefits from commercial forestry under Faustman optimal rotation under deterministic conditions, and flow values of land set aside for biodiversity protection. Separability is assumed between the provision of merchantable goods and biodiversity.

The utility flow of a forest owner, which is also supposed to be the manager, in period t is obtained from net returns from the area of commercial forests, A_t^C, and from the area preserved for biodiversity protection, A_t^B. In each time period the owner sets aside x_t for biodiversity protection. We simplify by assuming non-growth in biodiversity in the protected areas, and the dynamics of A_t^B is then given by

$$A_{t+1}^B = A_t^B + x_t \qquad (1)$$

The forest owner obtains rents in present terms per ha, Y, from the area of optimally managed commercial forest management under Faustman rotation, $A_t^C = A_0^C - A_t^B$, where A_0^C is the initial forest area for timber production and A_t^B is the area set aside for non-timber production The land owner also derives values from the land set aside, $v(A_t^B)$. Total welfare flow from land, V_t, is then written as (see e.g. Pong and Löfgren, 2009)

$$V_t = \rho Y(A_0^C - A_t^B) + v(A_t^B) \qquad (2)$$

where ρ is the discount rates. The first term at the RHS shows the annual rental flow from the area of commercial forestry and the second the value flows from the area conserved for non-timber products.

In order to obtain a cost function for biodiversity protection, it is assumed that the social planner imposes requirements of minimum conversion area, x_t*, in each time period. This is in accordance with the Swedish programs where the areas of land suitable for habitats are established by regional authorities and, depending on the potential biodiversity of the land in question, conversion is either statutory or voluntary (see further descriptions in Section 3). The forest owner is then assumed to maximize total value under restriction on minimum conversion in each period of time and dynamics of the biodiversity preservation areas, which is written as

$$Max \quad \sum_{t=0}^{\infty} \delta_t V_t \quad s.t. eq.(1), x_t \geq x_t^*, \; A_0^C > 0, \; A_0^B \geq 0 \qquad (3)$$

where $\delta_t = 1/(1+\rho)$ is the discount factor The associated Lagrangian is

$$L = \sum_{t=0}^{\infty} \delta_t \left[\rho Y(A_0^C - A_t^B) + v(A_t^B) + \alpha_t (x_t - x_t^*) + \delta \lambda_{t+1} (A_t^B + x_t - A_{t+1}^C) \right] \qquad (4)$$

which delivers the first order conditions as

$$\frac{\partial L}{\partial x_t} = \delta_t \left[\alpha_t + \delta \lambda_{t+1} \right] = 0 \qquad (5)$$

$$\frac{\partial L}{\partial A_t^B} = \delta_t \left[\frac{\partial v}{\partial A_t^B} - \rho Y + \delta \lambda_{t+1} - \lambda_t \right] = 0 \quad (6)$$

In steady state where society has reached the desired areas of biodiversity protection $x_t=0$, and eqs. (5) and (6) hold. From (5) we then obtain $\lambda=(1+\rho)\alpha_t$, which is inserted in (6) generating the necessary compensation payment where

$$c = Y - \frac{1}{\rho} \frac{\partial v}{\partial A_t^B} \quad (7)$$

According to (7) the optimal lump sum payment per unit of land set aside is determined by the foregone net returns from commercial forests minus the discounted streams of values from biodiversity conservation from a marginal area of land conversion.

From eq. (7) we can express an equation for optimal compensation payment as a function of the given parameters determining the opportunity cost of land, Y, and the preferences for biodiversity protection, $v(A^B)$. Opportunity cost of land is determined by the exogenous variables: output prices, **p**, prices of production factors, **w**, and forest growth conditions, **C,** and the biodiversity preferences are expressed by a vector, **M**, containing environmental preferences. We would expect compensation payments to be increasing in the output prices and favorable forest growth conditions, and decreasing in factor prices, the discount rate, and biodiversity preferences.

3. Brief presentation of data

The estimates of cost functions rest on existing panel data sets on two types of compensation payments; biotope protection and nature conservation agreements. Biotope protection is a statutory instrument designed to protect individual key habitats that are regarded as important environments for threatened plants or animals (Swedish Forest Agency, 2010). The ownership of the land is not affected, but the land owner is compensated for the decrease in the value of the estate. Any activity that could harm the natural values of the protected area is prohibited by law. Biotope protection areas are restricted in size to a maximum of 20 hectares, and the average size is approximately 3 hectares. Nature conservation agreement is a voluntary agreement between the state and the land owner, which is limited in time, normally to 50 years. Nature conservation agreements are suitable for areas that have high nature values, or for areas with a potential to develop high nature values by managing the forests in a way to promote nature values.

Data on compensation payments and areas of protection and conservation forests are available at the county level since 1998 (Swedish Forest Agency, 2010). Sweden is an elongated country with different climatic zones which affect the growth rate in forests. The counties are therefore categorized according to the most commonly occurring forest ecological systems in each county. Four vegetation zones are identified in Sweden (excluding the alpine/subalpine zone) – the northern and southern boreal zone, the boreonemoral zone and the nemoral zone. In the next Section 4 we will estimate region specific regression equations and overall regression equations with dummies for the ecological regions.

More detailed data over state compensations for habitat protection areas and nature conservation agreements of productive forest land in Sweden have been obtained from the Swedish Forest Agency (2010). The dataset yields the area of productive forest land protected and the compensation paid in 21 counties annually from 1998 to 2009. The compensations for biotope protection and nature conservation agreements vary considerably and the data for the two different types of forest land protection are therefore treated separately.

The choice of independent variables is based on results from the theoretical Section 2, other studies and availability of data. However, as reported in the introduction, there is, to the best of our knowledge, no study estimating cost functions for biodiversity protection in forests based on revealed enrolment of conservation areas and actual payments. Comparisons are therefore made with studies relying on stated preference data (Sikkamäki and Layton, 2007; Barton et al., 2009; Börner et al. 2009; Layton and Siikamäki 2009; Illukpitiya and Yanagida, 2010). However, all of the studies except for Sikkamäki and Layton, 2007 and Layton and Siikamäki (2009) are applied to tropical forests. They develop a beta-nominal model to predict voluntary participation by private landowners in forest conservation programs in Finland. The purpose of their studies was to predict enrolment in three different designs of the programs with respect to lump sum payment per hectare and contract length. The dependent variable is probability of enrolling different levels of ha, and the independent variables include payment, length of contract, set-aside land, dummies for different regions in Finland, expectation of timber prices, full time farmer, familiarity with the program, gender, non-forestry income, and age. The results show significant coefficient estimates at the 5 per cent level for all these variables.

A main difference of this study compared with Sikkamäki and Layton (2007) and Layton and Siikamäki 2009 is the choice of dependent variable. As reported above the land owner can not choose the number of ha for habitat protection since these are statuary, and the payments for given conservation areas are negotiated. Therefore, protection areas are regarded as exogenous to the farmers and compensation payments as endogenous. Similar to Sikkamäki and Layton (2007) and Layton and Siikamäki (2009) we introduce output prices, regional dummies as explanatory variables, and a regional income per capita as a proxy for non-forest incomes.

Following the theoretical derivations in Section 2 two types of inputs are included, labor and capital. The factor price of financial capital - assumed here as the average annual interest rates of Swedish Government Bonds with a maturity period of 10 years - has been obtained from the Riksbank (2010), while the cost of labor within the forestry sector has been obtained from the Swedish Forest Agency. Prices of forestry products – saw logs and pulpwood – are also obtained from the Swedish Forest Agency and show the weighted average of output prices of spruce and pine.

As factors determining the values of biodiversity we include share of votes on the Swedish Environmental Party, share of the county covered by forests, and also population density. The first is assumed to reflect the general environmental attitudes in the county, the share of forest area may influence the willingness to set aside for biodiversity purposes, and population density is a proxy for the recreational values of the forest but also for pressure of land for urban development.

All data on compensation payments, output and input prices have been adjusted for inflation using the Statistics Sweden consumer price index, and all costs are given in 2007 prices.

Variable abbreviations and explanations are presented in Table 1, and the descriptive statistics in Table 2.

[Table 1]
[Table 2]

The payment/ha for biotope protection is approximately 7 times higher than that for conservation agreement, 60 000 SEK as compared with 8 700 (1 Euro = 8.78 SEK, February 13, 2011). The relatively low compensations paid for nature conservation agreements arise from the differences in the restrictions in land use and from the temporal limitation of the agreement.

Except for wages and interest rates all mean values of the variables varies among the three forest regions, see Table 3.

[Table 3]

The payment/ha for habitat protection is highest in mid Sweden, and of equal size in the other two regions. The corresponding conservation payment is lowest in north and highest in the south. It is approximately 2/3 higher in south. It can also be noticed that the output prices of both saw log and paper and pulp timber are highest in the south. This can be a reflection of differences in transport costs due to the more densely population regions in south.

4. Econometric analyses

There are several ways of inferring impacts on response variable from the set of explanatory variables, in our case reported in Table 2. The easiest way might be to plug in the variables into a regression equation and carry out regression analysis. A statistical problem that may emerge in our case is associated with multicollinearity creating inefficient results. In order to mitigate this problem we apply a two step approach where we first investigate the dimensionality of the explanatory variable matrix by using principal component analysis, (PCA). Next, we carry out multiple regression analyses based on the results obtained from the PCA.

4.1 Dimensionality

It can sometimes be difficult to *a priori* delineate if and how a set of variables is correlated among themselves. Interdependence multivariate methods such as principal components analysis, factor analysis and cluster analysis are data reduction techniques used for this purpose. The PCA forms new linear combinations of variables by taking weighted averages of the original set of variables reducing it to a few composite indices. These new composite indices are uncorrelated among themselves and explain the maximum amount of variance in the data. PCA is used in this study in order to explore the existence of different clusters – economic and environmental attitude - within the *X* matrix and to establish a space wherein the variance of the *Biopayr* and *Conspayr* responses may be depicted.

However, before applying the PCA we take a further look at the distributions of the variables. It then turns out the *Biopayr*, *Conspayr, Bioha, Consha*, and *popdens* are highly skewed, and we therefore take the logarithm of these variables. The new variables are denoted *Biopayrl, Conspayrl, Biohal, Conshal,* and *popdensl.*

With a total of 9 potentially explanatory variables contained in *X*, the total standardized variance is 9. Figure 1 displays that the first factor reduces the information content with approximately 5.5 from 9 to 3.5, the second with 1.5 from 3.5 to 2.1, and so on.

[Figure 1]

The results presented in Figure 1 show strong similarities for the two payments systems. Four factors contribute with information content above or close 1, which are of main interest since contributions below 1 are less than contributions by single variables which is not meaningful. Hence, four orthogonal coordinate axes are required to unambiguously reproduce the observed matrix of the explanatory variables (approximately). The variables in each factor are the same for both payments schemes (see Tables A1 and A2 in the appendix). The first cluster conveys information from a linear combination of *wr, rr* and *Year*. The second by that of the *Forshare* and *MP*, the third of the output prices *Spr* and *Ppr*, the fourth by *Popdensl*, and the fifth *Biohal* or *Conshal*. These five components explain more then 90 per cent of variation in the explanatory variables.

4.2 Regression results

Results from the PCA in Section 4.1 indicate the use of five different explanatory variables. Separate regressions are made for habitat protection and conservation agreements, and also at the national and the forest regional levels. Since *Popdensl* carries own information it is introduced as independent variable. Three variables – *wr, rr,* and *yea*r – together explain a relatively large part of the variance for national and regional analyses. We will introduce *wr* and *rr* as explanatory variables because of their clear economic interpretation. The output price of paper and pulp, *Ppr*, has the largest content of information in the second component, and is therefore introduced. The third component consists of *Forshare* and *Mp*, and since we are mainly interested in the explanatory power of environmental attitudes we introduce *Mp* in our main analyses. Regressions are also carried out with *Forshare* as independent variable.

Our data set, with observations at the county level for the period 1998-2009, allows for the control of unobserved region specific characteristics. In principle there are two main methods for analyzing panel data – fixed and random effects models – which differ with respect to assumptions on region specific factors. The fixed effects explore relations within a region while random effects assume that variation across regions is random and uncorrelated with the explanatory variables. Our prior belief is that differences among regions affect the dependent variables and the random effect model is therefore most appropriate. We will, however, carry out and report the Hausmann tests for random effects.

[Table 4]

The results for the two types of payment systems are similar; all coefficients are of the same sign but of different statistical significance. The coefficients for *Biohal*, *Conshal*, and *Popdensl* can be expressed in terms of elasticities, i.e. the percentage change in payments from one percent change in protection or conservation areas. Estimates of the coefficients for *Biohal* and *Conshal* are both significant, positive and of the same order of magnitude, 0.798 and 0.788 respectively. The estimated coefficients for *Popdensl* are also positive and significant, and may reflect a higher value of land in densely populated regions. A candidate interpretation is that payments increase as the area of forest land becomes smaller. Another common result is the positive and significant coefficients of *wr* and *rr*. The positive sign of *rr* is expected from the theoretical section, but not that of *wr*. If *wr* reflects input costs the sign should be negative. Since *wr* is the wage rate in the forest sector it should show the input cost in this sector. If the wage rate in this sector is correlated with the general wage rate it could instead be interpreted as a reservation wage for forestry, and then have a positive impact on compensation payments. A third common result is the non-significant estimate of the coefficient for the output price *Ppr*, although the positive sign is expected

The main differences between the two models are the significant coefficient estimate of *Mp* on *Conspayrl* and that of the regional dummies on *Biopayrl*. The negative sign is expected, and the significant estimate only for *Conspayrl* may reflect that these are voluntary agreements. Environmental preferences in the counties may not impact the market prices of forest land which determine the compensation payments under biotope protection schemes. The results indicate that the opposite is the case for differences in forest growth conditions among regions as shown by the significant effects of the dummies on *Biopayrl.*

The separate regional estimates of payments for biotope protection, *Biopayrl*, also show similarities; payments increase significantly for larger areas for the north and mid regions, see Table 5.

[Table 5]

A common result for all regions is the significant and positive estimate of the coefficient for *Wr*. A noteworthy result is that the estimated coefficient for the output price is significant and positive for all regions but *South*. When instead estimating regression equations for payments for conservation agreements, i.e. with *Conspayrl* as the response variable, output price is significant and positive only for the North region, see Table 6.

[Table 6]

All significant coefficient estimates have the same signs as those reported in Tables 3 and 4. The estimates for one region, South, show some opposite results for non-significant estimates for both the responses. Unlike the estimates for habit protection, area of biodiversity protection is significant and positive for all three regions.

5. Conclusions

The purpose of this paper has been to test the power of different explanatory variables for the size of payments for two types of habitat preservations in Sweden: habitat protection where land is set aside and conservation agreements which allow for some forestry activities. A panel data set is used for different counties during the period 1998-2009. We used a two step approach where the choice of explanatory variables to be included in the regression equations was made by means of principal component analysis (PCA).

Separate regressions were made for the two types of payments schemes. We would expect differences in explanatory power between the schemes since they are subjected to different regulations. Payments for habitat protection shall correspond to the market value of land, and is thus determined by variables affecting the land values such as output and input prices and the discount rate. Conservation payments are agreed upon by the land owner and the authority and gives room for other factors affecting the level such as environmental attitudes. Eight different explanatory variables were identified for the PCA for both payment systems; area of biodiversity protection, interest rate, wage rate, price of paper and pulp, price of saw products, environmental attitudes as revealed by share of votes on the Swedish environmental party, population density, and area of forests in relation to total area.

The results from the principal component were the same for both types of payments schemes; five similar clusters explain more than 90 per cent of the variance. Using random effects regression models the results show significant effects on costs from changes in areas of habitat protection; the cost increase from 1 per cent increase in the protected areas varies between 0.75 and 0.90 per cent depending on type of payment scheme and region. Another result common to all specifications is the significant and positive effect of the wage rate in the forestry sector, the sign of this is unexpected from the theoretical section. In general, we would expect increases in input prices to reduced current and future streams of profits from forestry and thus reduced the required compensation payment for biodiversity protection. However, if the wage rate in the forestry sector is correlated with the general wage rate it can be interpreted as a reservation wage for forestry, and then have a positive impact on compensation payments. A third result common to most specifications is the significant and positive effects of population density, which may reflect the higher values of forest land in regions with competition of land for urban development.

The main difference in results between the two compensation systems is the significant and negative effects of environmental attitudes on payments for conservation agreements and the significant impacts of regional dummies on payments for habitat protection. Since compensation payments for conservation are voluntary and determined by negotiations we would expect more room for other factors than those directly affecting the value of forest land, and the negative effect of environmental attitudes then reflect land owner’s preferences for biodiversity protection.

Appendix: Tables and figure

[Table A1]
[Table A2]
[Table A3]
[Figure A1]

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Table 1: Variable abbreviations and explanations

Biopayr	Costs for biotope protection, thousand SEK
Conspayr	Costs for voluntary agreements on conservation, thousand SEK
Bioha	hectares of habitat protection
Consha	hectares of conservation agreements
wr	real wage rate in the forestry and agricultural sector, sek/hour
Rr	real interest rate on governmental 10 year bonds
Ppr	real paper and pulp output prices, SEK/m^3
Spr	real saw timber prices, SEK/m^3
Incapr	real income per capita, thousand SEK/capita
Mp	share of votes on the Environmental party aggregated from the municipality level
Popdens	population density, 100 000/km^2
Forshare	forest area/total area

Table 2: Descriptive statistics four data at the county level between 1998-2009

Variable	*Obs*	*Mean*	*Std.*	*Min*	*Max*
Mp	251	0.033	0.009	0.018	0.062
Popdens	251	0.043	0.060	0.003	0.310
Incapr	251	177	28	124	307
Forshare	251	0.592	0.136	0.334	0.837
Wr	251	114	7	103	123
Rr	251	4.83	0.99	3.25	6.16
Spr	251	424	46	285	503
Ppr	251	262	30	201	324
Biopayr	251	4227	2838	118	13588
Conspayr	240	1057	1048	0	7050
Bioha	251	71	54	2	296
consha	240	122	181	0	1716

Table 3: Descriptive statistics for the three Swedish forest regions

Variable	*North*			*Mid*			*South*		
	Obs	*Mean*	*Std.*	*Obs*	*Mean*	*Std.*	*Obs*	*Mean*	*Std.*
Mp	83	0.031	0.007	132	0.035	0.010	36	0.029	0.004
Popdens	83	0.009	0.005	132	0.058	0.074	36	0.070	0.026
Incapr	83	173	19	132	182	35	36	174	17
Forshare	83	0.641	0.156	132	0.581	0.115	36	0.521	0.119
Spr	83	404	36	132	432	46	36	441	56
Ppr	83	256	30	132	265	29	36	269	34
Biopayr	83	6023	3035	132	3696	2345	36	2031	1309
Conspayr	77	1640	1327	128	862	801	35	487	379
Bioha	83	112	65	132	54	33	36	38	20
consha	77	212	242	128	90	137	35	41	30

Table 4: Regression results from two models at the national level with random effects

	Biopayrl, n=251		*Conspayrl, n=240*	
	Coefficient	*p-value*	*Coefficient*	*p-value*
Biohal	0.798	0.000		
Conshal			0.869	0.000
Popdensl	0.123	0.000	0.113	0.024
Mp	-1.48	0.568	-6.036	0.097
Wr	0.044	0.000	0.063	0.000
Rr	0.088	0.053	0.159	0.005
Ppr	0.00036	0.67	0.0016	0.023
North	0.187	0.016	-0.028	0.776
South	-0.442	0.009	-0.089	0.510
Constant	-0.118	0.90	-4.91	0.000
Wald chi2	p=0.0000		p=0.0000	
Hausmann test for random effects	Chi2 = 0.80, p=0.94		Chi2 = 5.42, p=0.25	

Table 5: Regression results with habitat protection payments, *Biopayrl,* as dependent variable for three different Swedish forest regions

	North, n=83		*Mid, n=132*		*South, n=36*	
	Coeff.	*P*	*Coeff*	*p*	*Coeff*	*p*
Biohal	0.853	0.000	0.916	0.000	0.100	0.848
Popdensl	0.211	0.000	0.117	0.007	0.517	0.473
Mp	-10.9	0.207	2.28	0.514	9.01	0.816
Wr	0.066	0.000	0.033	0.000	0.072	0.047
Rr	0.122	0.160	0.024	0.670	0.191	0.451
Ppr	0.0028	0.034	0.0017	0.024	-0.006	0.15
Constant	-4.70	0.009	0.621	0.602	0.687	0.88
Wald chi2	p=0.0000		p=0.0000		p=0.0000	

Table 6: Regression results with *Conspayrl* as dependent variable for three different Swedish forest regions

	North, n=83		*Mid, n=132*		*South, n=36*	
	Coeff.	*P*	*Coeff*	*p*	*Coeff*	*p*
Conshal	0.853	0.000	0.759	0.000	0.804	0.000
popdensl	0.211	0.000	0.097	0.198	-0.328	0.101
Mp	-10.91	0.207	-3.12	0.472	9.44	0.626
Wr	0.066	0.000	0.093	0.001	0.054	0.027
Rr	0.122	0.16	0.269	0.013	0.203	0.157
Ppr	0.0028	0.034	-0.0007	0.580	0.00073	0.54
Constant	-4.70	0.009	-8.028	0.009	-5.41	0.070
Wald chi2()	p=0.0000		p=0.0000		p=0.0000	

Table A1: Principal components in the *Biopayrl* explanatory matrix

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
biohal	0.0920	-0.4266	-0.1704	0.2751	0.7460	0.1864
popdensl	0.0106	0.4006	-0.1841	-0.6554	0.1767	0.0458
forshare	0.0048	-0.1276	0.6800	-0.2165	-0.0107	0.6874
incapr	0.3646	0.2192	-0.1281	-0.3189	0.4337	0.0698
mp	-0.1159	0.2104	-0.5927	0.2297	-0.2274	0.6934
wr	0.5141	0.0744	0.0293	0.1380	-0.0453	0.0339
rr	-0.5032	-0.0589	-0.0152	-0.0812	0.2610	-0.0201
ppr	-0.0350	0.5260	0.2555	0.4389	0.1803	-0.0520
spr	-0.2533	0.5006	0.1940	0.2186	0.2578	0.0185
year	0.5120	0.1123	0.0542	0.1650	-0.0562	0.0181

Table A2: Principal components in the *Conspayrl* matrix

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
conshal	0.2694	-0.2325	0.0096	-0.3044	0.8048	0.2648
popdensl	-0.0404	0.4200	-0.2499	0.6149	0.1953	0.0063
forshare	-0.0040	-0.2305	0.5699	0.3874	-0.1577	0.6666
incapr	0.3276	0.3059	-0.1526	0.3500	0.2807	0.1463
mp	-0.1008	0.2791	-0.5031	-0.3676	-0.2510	0.6770
wr	0.5013	0.1030	0.0671	-0.0609	-0.1585	-0.0287
rr	-0.4923	-0.0584	-0.0145	0.0319	0.2641	0.0317
ppr	-0.0374	0.5209	0.4459	-0.3007	0.0362	-0.0490
spr	-0.2504	0.4908	0.3490	-0.1379	0.1745	0.0261
year	0.5005	0.1369	0.1043	-0.0857	-0.1445	-0.0267

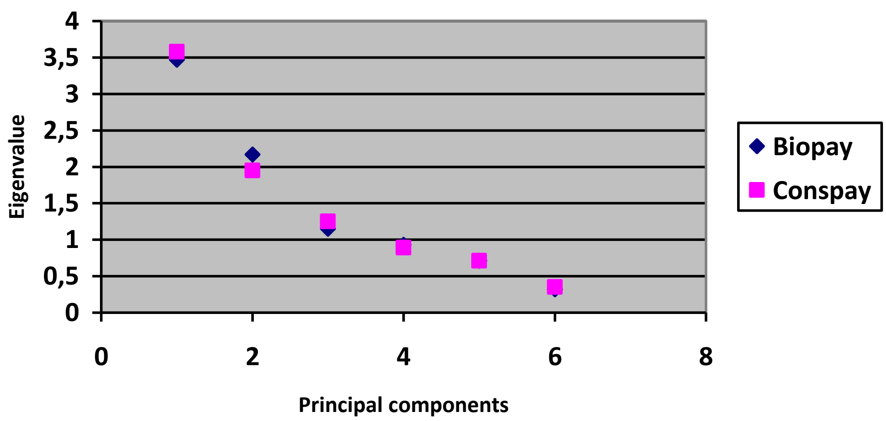

Figure 1: Principal component analyses at the national level with Biopayrl and Conspay as response variables